Solar Dynamics Observatory

Activity Name	Grades	Suggested Activity Time	Prep Time	Materials**
Resolution Matters	4-8	15-20 min	15 min*	SDO images (see pages 4-7), 1 set DUPLO blocks, 1 set LEGO blocks

*This is the estimated preparation time once you have already obtained the LEGO and DUPLO blocks.

Objectives- Students will be able to:

- Construct a model of the Sun and its sunspots using LEGO and DUPLO blocks
- Explain what image resolution is
- Describe how advancements in technology benefit science

Description:
Students will investigate the importance of technological advancement to science. They will recreate a solar image taken by the Solar Dynamics Observatory (SDO) using DUPLO and LEGO blocks, and discuss how their recreations relate to image resolution. Students will also compare SDO images to solar images from older spacecraft to see how improved technology helps scientists learn more about the Sun.

How to Prepare:
Print out one copy per group of the images on pages 4, 5, and 7 (page 6 is optional). It is suggested to print them out on 8 ½ x 11-inch paper or larger. Set out the LEGO and DUPLO blocks separately (for purchasing information, see page 3). Students are expected to have a basic understanding of image resolution and pixels prior to doing this lesson.

Background Information:
The Solar Dynamics Observatory (SDO) was launched on February 11, 2010 from Cape Canaveral, Florida. It is the first mission to be launched for NASA's Living With a Star Program, a program designed to understand the causes of solar variability and its impacts on Earth. SDO is not the only spacecraft currently studying the Sun and its impacts on Earth; other spacecraft include the Solar and Heliospheric Observatory (SOHO) and Solar TErrestrial RElations Observatory (STEREO), which were launched in 1995 and 2006, respectively. Although SOHO and STEREO provide scientists with important data, SDO's AIA instrument (see image 3 on page 6) has twice the image resolution than STEREO (see image 2 on page 6) and four times greater imaging resolution than SOHO (see image 1 on page 6). The image cadence also varies. SDO takes one image every second while, at best, STEREO takes one image every three minutes and SOHO takes one image every 12 minutes. This is important because increased image resolution and cadence allows scientists to better understand the Sun and its

mechanics. With improved technologies, researchers are enabled to learn more about the world we live in.

Vocabulary:

- pixel
- Solar Dynamics Observatory (SDO)
- Solar and Heliospheric Observatory (SOHO)
- sunspot
- visible light

Optional vocabulary:

- *electromagnetic spectrum*
- *image resolution*
- *ultraviolet light*

Directions:

1. Separate the class into two groups. Give each group a set of blocks and a copy of the SDO image on page 4. Ask them: What do you think this is a picture of? What are the black spots?
2. Explain that image of the Sun taken by SDO that is shown in visible light. (For older students, you can discuss how this image was taken by the AIA instrument at the 4500 Angstrom wavelength and discuss what they know about the electromagnetic spectrum.)
3. Point out to students that the black spots on the image are called sunspots. These are cooler, darker areas on the Sun that only last temporarily and can be as wide as the Earth! (For older students, you can explain that sunspots are areas where the magnetic field becomes concentrated on the Sun. Sunspots often correlate to active regions on the Sun that can cause solar eruptions, which is why scientists study them. For more on sunspots, see the Resources section below.)
4. Ask each group to recreate the image of the Sun (including sunspots) using the yellow and black LEGO or DUPLO blocks. Tell them to make their model look as close to the picture as possible.
5. Have students compare their model of the Sun to the other group's model. Ask them: Which model is a closer match? Which shows more detail? If you were studying the Sun using these models, which would give you more accurate information? (Note: The LEGO model should closer resemble the picture and show more detail.)
6. Discuss with students that if scientists were using these models to study the Sun, they would choose the LEGO model because more detail can be seen. If they have a clearer and more detailed picture of the Sun, they can learn more about what is happening on the Sun. To relate this concept to students' lives, ask them: (Younger students) If you were given a picture of a zebra and asked to count its stripes, would you rather look at a blurry picture or clear picture? Which would make it easier to count? (Older students) If you were asked to solve a crime, would the amount of detail on the image matter? Why?
7. Handout the sheet entitled "SDO vs. SOHO Images" (see page 5). Tell them that the picture on the top was taken by SDO and the image on the bottom was taken on the same day by SOHO, which is a Sun-studying spacecraft that launched 15 years before SDO. SDO takes images that are 4096 by 4096 pixels whereas the images taken by SOHO are only 1024 by 1024 pixels. (Write these numbers on the board to refer back to in step 10.) Ask students to compare the two images on the sheet. Ask them: Which shows more detail (has better image resolution)? Which one would you want to use if you were trying to study a specific feature of the Sun? Have them justify their answers.
8. Students should recognize that SDO cameras have four times the detail (four times greater imaging resolution) than SOHO, which is important because increased detail allows scientists to better understand the Sun and its mechanics (see Background Information for more).
9. (*Optional*) For older students, you can discuss how the images on page 5 were taken at the 171 Angstrom wavelength. This means that these images capture the Sun in extreme ultraviolet (EUV) light, which is what scientists call ultraviolet light with the shortest wavelengths; in terms of UV light, EUV light is furthest from visible light in the electromagnetic spectrum.
10. Discuss that advances in technology, including those that provide us with higher resolution images of

the Sun, help drive scientific discovery. Show students the diagram on page 7 that shows the relative image resolution of images from the aforementioned satellites, and standard definition (SD) and high definition (HD) TV. Revisit the list made in step 7 on the board and record that a typical SD TV has a resolution of 640 by 480 pixels while a typical HD TV is 720 by 1080 pixels. To make the list complete, the resolution of the STEREO satellite can be written on the board, which is 2048 by 2048.
11. (*Optional*) Using the list on the board, have students compare the different resolution values for the items on page 7 and determine how much greater the imaging resolution is of one item compared to another. For example, SDO has four times greater imaging resolution than SOHO and two times greater imaging resolution than STEREO.
12. Ask students to reflect upon technology they commonly use and come up with instances where they witnessed increases in image resolution in these technologies (i.e. standard TV to HD TV, improved digital cameras, VHS to DVD to Blu-ray discs).
13. To assess students, have students elaborate on what they learned by writing a paragraph about what resolution is, and how advances in technology affect science and their every day lives.

Resources:

- NASA—Exploring the Sun: http://sohowww.nascom.nasa.gov/classroom/Explore_print.pdf
- NASA—NASA's New Eye on the Sun Delivers Stunning First Images: http://www.nasa.gov/mission_pages/sdo/news/first-light.html
- NASA— Solar and Heliospheric Observatory (SOHO): http://sohowww.nascom.nasa.gov
- NASA—Solar Dynamics Observatory (SDO): http://sdo.gsfc.nasa.gov
- NASA—Ultraviolet Waves: http://missionscience.nasa.gov/ems/10_ultravioletwaves.html
- UC Berkeley Space Sciences Laboratory—Sunspots: http://cse.ssl.berkeley.edu/segwayed/lessons/Sunspots/

Standards addressed:

A. National Standards addressed:

K-4: *Content Standard A:* As a result of their activities in grades K-4, all students should develop the abilities necessary to do scientific inquiry, and 3: employ simple equipment and tools to gather data and extend the senses; *Content Standard E:* As a result of their activities in grades K-4, all students should develop understandings about science and technology, 5: Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure, and do.

5-8: *Content Standard E:* As a result of their activities in grades 5-8, all students should develop understandings about science and technology, 3: Science and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis.

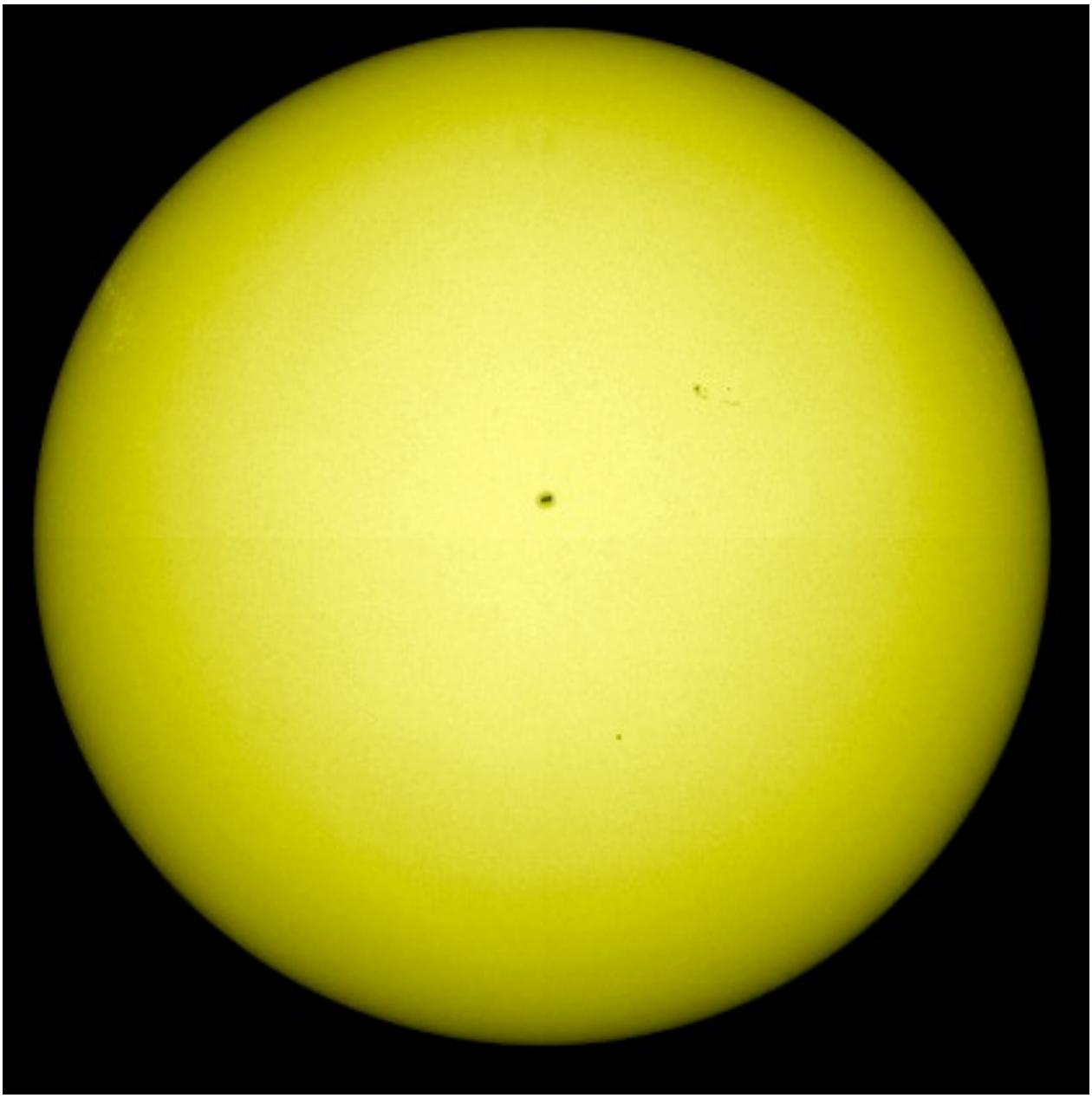
****Purchasing information for materials:**

The LEGO and DUPLO materials can be purchased at www.lego.com or by calling LEGO at 1-800-835-4386. The blocks used in this lesson are yellow and black. Product information is as follows:

- For one DUPLO set: one building plate (product #2304), 50-75 yellow bricks (product #343724), 10-15 black bricks (product #343726)—order the bricks through "Replacement Bricks"

- For one LEGO set: one building plate (product #628), 100-150 yellow bricks (product #300324), 20-25 black bricks (product #300326)—order the bricks through "Pick-a-Brick"

Image taken by the Solar Dynamics Observatory on 8/10/2010



SDO images vs. SOHO images

Which image shows more detail?

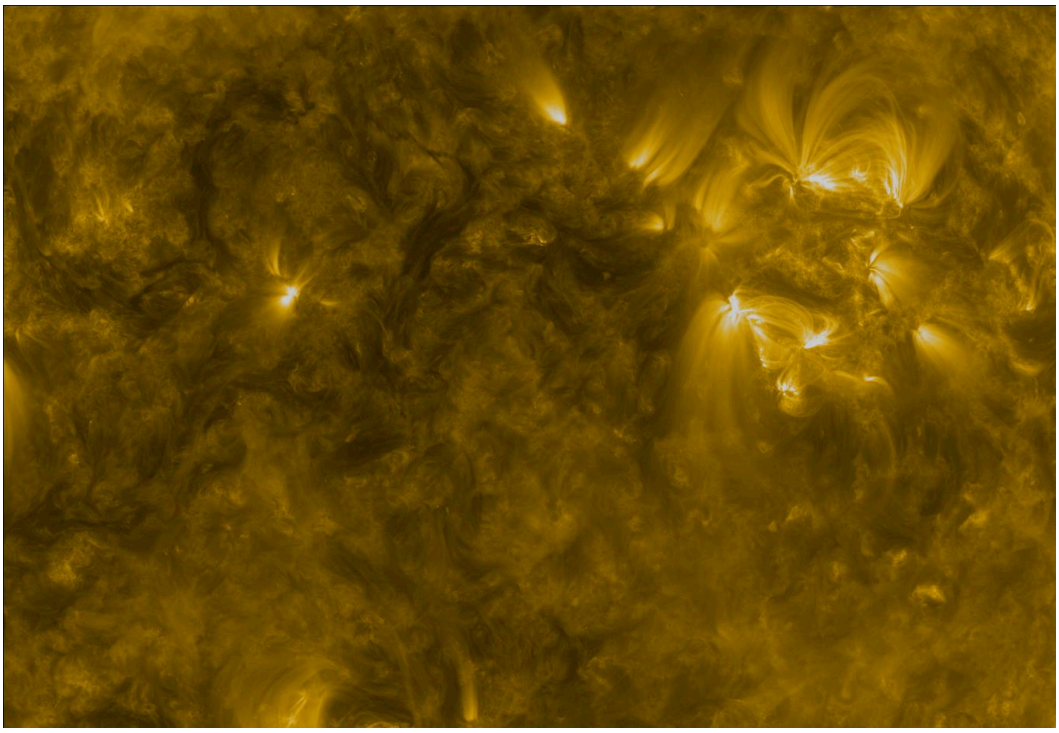


Image taken by the Solar Dynamics Observatory (SDO) on 9/2/2011.
SDO launched in 2010.

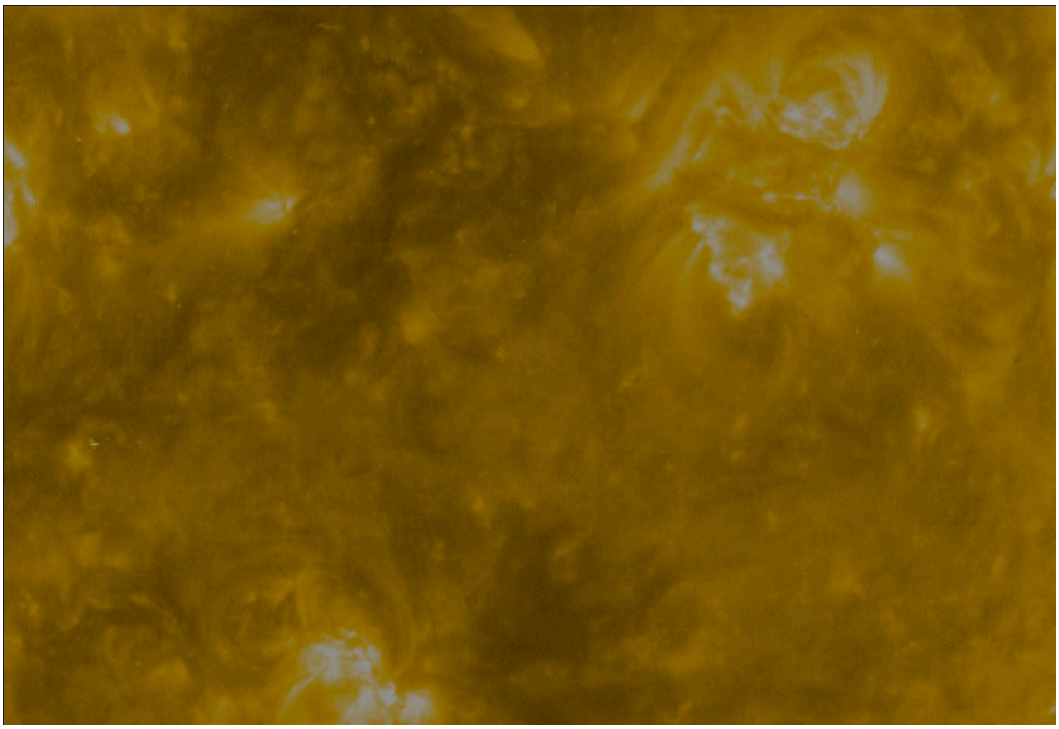


Image taken by the Solar and Heliospheric Observatory (SOHO) on 9/2/2011.
SOHO launched in 1995.

Resolution Comparison for NASA Satellites

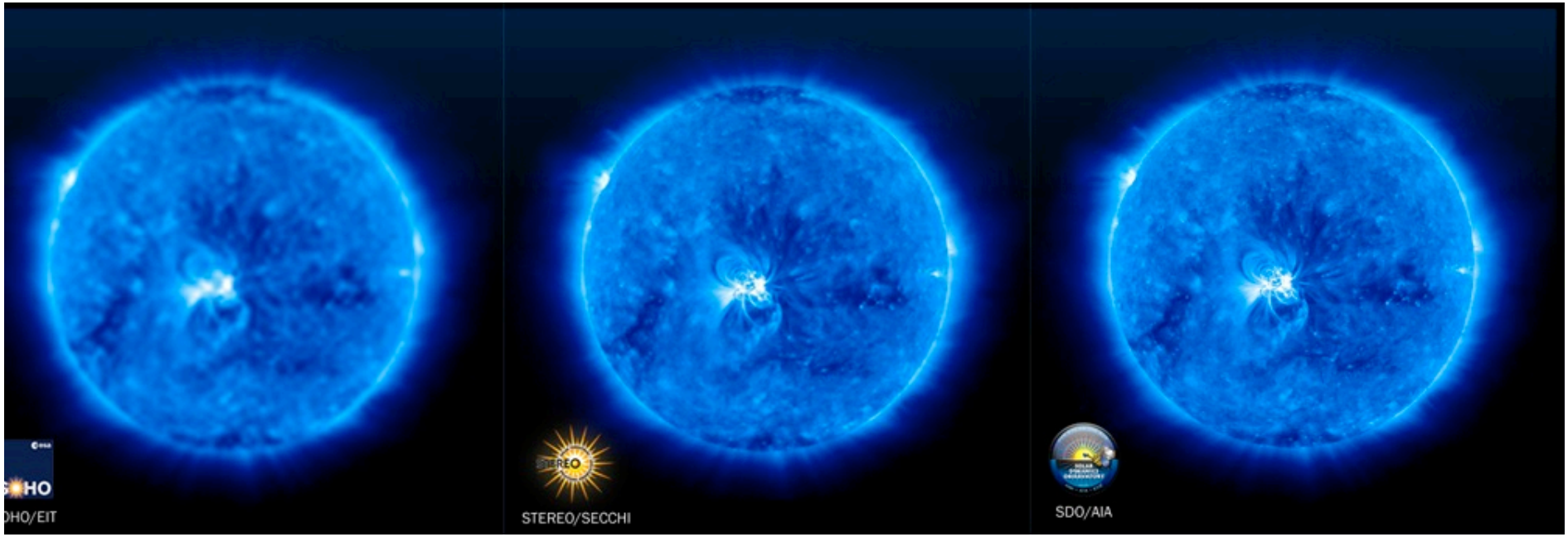


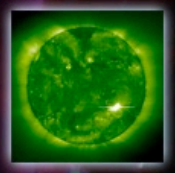
Image 1

Image 2

Image 3

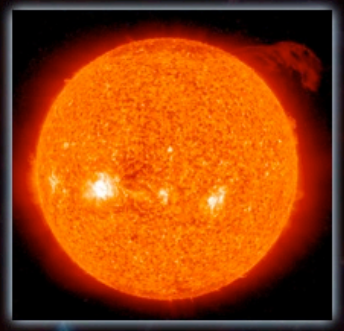
Relative Image Resolution

480 Standard Definition TV

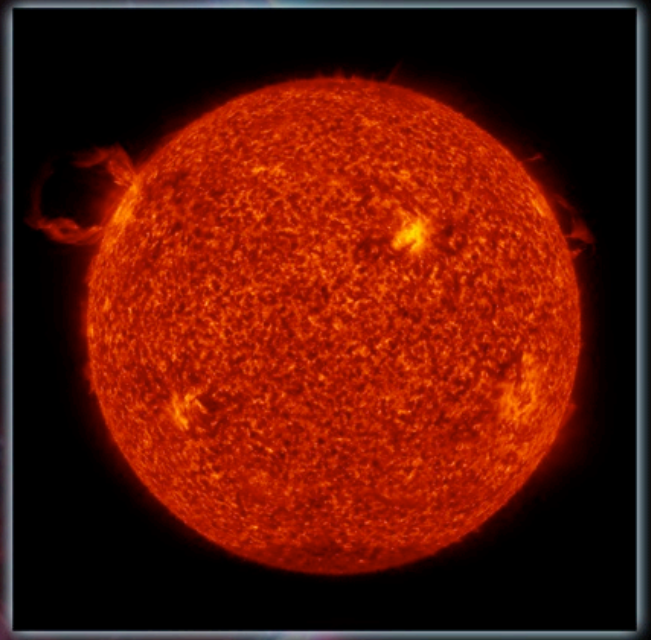


SOHO

1080 High Definition TV



STEREO



SDO